8024

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) Internati nal Patent Classification 6 :
H02K 3/48

A1

(11) International Publicati n Number: **WO 97/45934**

(43) Internati nal Publicati n Date: 4 December 1997 (04.12.97)

(21) International Application Number: PCT/SE97/00896

(22) International Filing Date: 27 May 1997 (27.05.97)

(30) Priority Data:

9602079-7	29 May 1996 (29.05.96)	SE
9602084-7	29 May 1996 (29.05.96)	SE

(71) Applicant (*for all designated States except US*): ASEA BROWN BOVERI AB [SE/SE]; S-721 83 Västerås (SE).

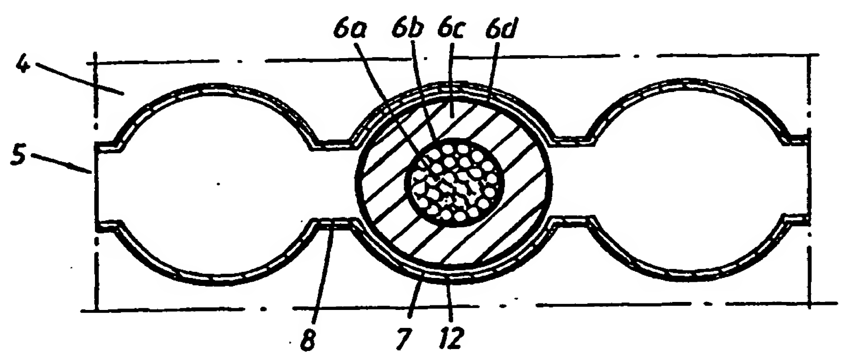
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): LEIJON, Mats [SE/SE]; Hyvlargatan 5, S-723 35 Västerås (SE). ROTHMAN, Bengt [SE/SE]; Profilgatan 16, S-723 36 Västerås (SE).

(74) Agent: KARLSSON, Leif; L.A. Groth & Co. KB, P.O. Box 6107, S-102 32 Stockholm (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, FI (Utility model), GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A ROTATING ELECTRIC MACHINE AND A METHOD OF MANUFACTURING THE SAME



(57) Abstract

The invention relates to a rotating electric high-voltage machine, the stator winding of which comprises high-voltage cables (6) arranged in radial slots (5) in the core of the stator (1). The machine is designed for direct connection to a power network without intermediate transformers. According to the invention the slots (5) are provided with a lining (12) of thermoformable material such as aramid fibre and have a profile conforming with the profile of the slot (5). The lining (12) enables a high-voltage cable (6) with an outer surface of a semiconducting layer (34) to be inserted in the slots without risk of being damaged.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

A ROTATING ELECTRIC MACHINE AND A METHOD OF MANUFACTURING THE SAME

The present invention relates in a first aspect to a rotating electric machine of the type described in the preamble to claim 1, e.g. synchronous machines, but also double-fed machines, applications in asynchronous static current converter cascades, outer pole machines and synchronous flow machines.

A second aspect of the invention relates to a method of the type described in the preamble to claim 15.

The machine is intended primarily as generator in a power station for generating electric power. The machine is intended for use with high voltages. High voltages in this respect are electric voltages in excess of 10 kV. A typical operating range for the machine according to the invention may be 36 to 800 kV.

Similar machines have conventionally been designed for voltages in the range 6-30 kV and 30 kV has normally been considered to be an upper limit. This generally means that a generator must be connected to the power network via a transformer which steps up the voltage to the level of the power network, i.e. in the range of approximately 100-400 kV.

By using high-voltage insulated electric conductors, in the following termed cables, in the stator winding, with solid insulation similar to that used in cables for transmitting electric power, e.g. XLPE-cables (XLPE = crosslinked polyethylene), the voltage of the machine can be increased to such levels that it can be connected directly to the power network without an intermediate transformer.

This concept generally requires that the slots in which the cables are placed in the stator are deeper than with conventional technology (thicker insulation due to higher voltage and more turns in the winding). In a machine of this particular type the slot has a depth corresponding to more than half, and normally more than two thirds of the radial extension of the core. This entails new problems with regard to mechanical natural frequencies in the stator teeth (the spaces between the stator slots) and their cooling.

Securing the cable in the slot is also a problem - the cable must be inserted into the slot without its outer layer being damaged. It is subjected to currents having a frequency of 100 Hz which cause a tendency to vibration and, besides manufacturing tolerances with regard to the outer diameter, its dimensions will also vary with variations in temperature (i.e. load variations).

Although the predominant technology when supplying current to a high-voltage network, a concept that in the present application relates to 70 kV and above, is to insert a transformer between the generator and the power network as mentioned in the introduction, it has already been endeavoured to eliminate the transformer by generating the voltage directly at the level of the network. Such a generator is described in US-4 429 244, US-4 164 672 and US-3 743 867.

It is considered that coils for rotating generators can be manufactured with good results within a voltage range of 3 - 25kV.

Attempts to develop the generator for higher voltages have, however, been in progress for a long time. Reference can be made, e.g., to "Electrical World", October 15, 1932, pages 524-525. This describes how a generator designed by Parson 1929 was arranged for 33 kV. It also describes a generator in Langerbrugge, Belgium, which produced a voltage of 36 kV. Although the article also speculates on the possibility of increasing voltage levels still further, the development was curtailed by the concepts upon which these generators were based. This was primarily because of the shortcomings of the insulation system where varnish-impregnated layers of mica oil and paper were used in several separate layers.

In a report from the Electric Power Research Institute, EPRI, EL-3391 from April 1984, an account is given of generator concepts for achieving higher voltage in an electric generator with the object of being able to connect such a generator to a power network without intermediate transformers. Such a solution is assessed in the report as offering good gains in efficiency and considerable financial advantages. The main reason that it was deemed possible in 1984 to start developing generators for direct connection to power networks was that a superconducting rotor had been developed at the time. The considerable excitation capacity of the superconducting field winding enables the use of

airgap-winding with sufficient thickness to withstand the electrical stresses.

By combining the concept deemed most promising according to the project, that of designing a magnetic circuit with a winding known as "monolithe cylinder armature", a concept in which two cylinders of conductors are enclosed in three cylinders of insulation and the whole structure is attached to an iron core without teeth, it was assessed that a rotating electric machine for high voltage could be directly connected to a power network. The solution entailed the main insulation having to be made sufficiently thick to withstand network-to-network and network-to-earth potentials. Obvious drawbacks with the proposed solution, besides its demanding a superconducting rotor, are that it also requires extremely thick insulation, which increases the machine size. The end windings must be insulated and cooled with oil or freones in order to control the large electric fields at the ends. The whole machine must be hermetically enclosed in order to prevent the liquid dielectric medium from absorbing moisture from the atmosphere.

Certain attempts at a new approach as regards the design of synchronous machines are described, inter alia, in an article entitled "Water-and-oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1, 1970, pp. 6-8, in US 4,429,244 "Stator of Generator" and in Russian patent document CCCP Patent 955369.

The water- and oil-cooled synchronous machine described in J. Elektrotechnika is intended for voltages up to 20 kV. The article describes a new insulation system consisting of oil/paper insulation, which makes it possible to immerse the stator completely in oil. The oil can then be used as a coolant while at the same time using it as insulation. To prevent oil in the stator from leaking out towards the rotor, a dielectric oil-separating ring is provided at the internal surface of the core. The stator winding is made from conductors with an oval hollow shape provided with oil and paper insulation. The coil sides with their insulation are secured to the slots made with rectangular cross section by means of wedges. As coolant oil is used both in the hollow conductors and in holes in the stator walls. Such cooling systems, however, entail a large number of connections of both oil and electricity at the coil ends. The thick insulation also

entails an increased radius of curvature of the conductors, which in turn results in an increased size of the winding overhang.

The above-mentioned US patent relates to the stator part of a synchronous machine which comprises a magnetic core of laminated sheet with trapezoidal slots for the stator winding. The slots are tapered since the need for insulation of the stator winding is less towards the interior of the rotor where that part of the winding which is located nearest the neutral point is located. In addition, the stator part comprises a dielectric oil-separating cylinder nearest the inner surface of the core which may increase the magnetization requirement relative to a machine without this ring. The stator winding is made of oil-immersed cables with the same diameter for each coil layer. The layers are separated from each other by means of spacers in the slots and secured by wedges. What is special for the winding is that it comprises two so-called half-windings connected in series. One of the two half-windings is located, centred, inside an insulation sleeve. The conductors of the stator winding are cooled by surrounding oil. The disadvantages with such a large quantity of oil in the system are the risk of leakage and the considerable amount of cleaning work which may result from a fault condition. Those parts of the insulation sleeve which are located outside the slots have a cylindrical part and a conical termination reinforced with current-carrying layers, the purpose of which is to control the electric field strength in the region where the cable enters the end winding.

From CCCP 955369 it is clear, in another attempt at raising the rated voltage of the synchronous machine, that the oil-cooled stator winding comprises a conventional high-voltage cable with the same dimensions for all the layers. The cable is placed in stator slots formed as circular, radially disposed openings corresponding to the cross-section area of the cable and the necessary space for fixing and for coolant. The different radially located layers of the winding are surrounded by and fixed in insulated tubes. Insulating spacers fix the tubes in the stator slot. Because of the oil cooling, an internal dielectric ring is also needed here for sealing the coolant against the internal air gap. The design shown has no tapering of the insulation or of the stator slots. The design exhibits a very narrow radial waist between the

different stator slots, which means a large slot leakage flux which significantly influences the magnetization requirement of the machine.

The present invention is related to the above-mentioned problems associated with avoiding damage to the exterior of the cable during insertion into the stator slots and avoiding wear against the surface caused by vibration during operation. Solving this problem would enable the use of cables in the cable windings that do not have a mechanical protective outer layer. The outer layer of the cable then consists of a thin semiconductor material which is sensitive to mechanical damage.

The object of the present invention is to provide a machine in which this problem is solved.

This object is achieved according to the invention in that a machine of the type described in the preamble to claim 1 is given the special features defined in the characterizing part of the claim and in that a method of the type described in claim 17 comprises the special measures defined in the characterizing part of this claim.

By thus arranging a lining in the slot, contact is eliminated between the outer layer of the cable and the parts of the stator core forming the walls of the slots. The material in the lining must be thermoformable so that it can be given a complicated configuration corresponding to that of the slot walls and substantially retain its shape after moulding. A lining can thus be obtained which is in contact with the slot walls, even if their profile is unusual, and without other aids such as glue or the like to hold the lining in place.

As known per se, the slots of a rotating electric machine are provided with some kind of lining, e.g. through US-3 943 392, US-3 130 335, and US-1 974 408. These linings, however, are not for high voltage machines, and are used in machines with another type of insulation system to that required in a machine according to the present invention. Thus this type of lining cannot be used to solve the problem of protecting the uncovered outer layer of such an insulation system.

US-2 749 456 reveals the arrangement of a lining in the stator slots of an electric motor to be known per se. However, the machine here is not one for high voltage. The motor is

designed in such a way that it is able to operate immersed in water and the lining is arranged to insulate the cable windings from the water. The problems encountered with the high-voltage levels are not relevant and the aim is not to provide any mechanical protection. The material in the lining is extruded polyvinyl chloride, which limits the freedom to produce a lining with properties enabling its use for a machine according to the present invention due, for instance, to formability, profile and thickness.

It is advantageous to manufacture a machine according to the invention with slots having varying width in radial direction, with alternating narrower and wider parts. The wider parts preferably have a circular cross section to allow passage of the cable, and are connected by waisted parts constituting narrower parts. The slots thus acquire a profile similar to that of a bicycle chain. The advantages of the lining according to the invention are particularly noticeable with such an embodiment where it has a corresponding profile.

The lining material is suitably fibre-reinforced, preferably with aramid fibres, so that it will withstand mechanical damage. Since it is thermoformable, the lining can be made relatively thin, approximately 0.1 - 1.0 mm, preferably 0.2 - 0.5 mm, which means that it takes up little useful room.

In a particularly preferred embodiment the lining includes spring means. This is achieved in an advantageous manner by manufacturing the lining in two layers with spring elements between the layers. A resilient lining offers the additional advantage that the cables can be positioned so that the vibrations are absorbed.

The embodiments described above and other advantageous embodiments of the invention are defined in the sub-claims to claim 1.

The method according to the invention defined in claim 15 describes how the lining can be manufactured and applied in the slots in a simple and expedient manner. Moulding the lining in the manner described enables a thin lining with complicated profile to be produced which can easily be inserted into the slot.

The method enables the lining to be inserted axially into the slot, thus simplifying assembly.

To achieve the desired profile of the lining when it is to be applied in a slot with "bicycle-chain profile", the sheet which is to form the lining is shaped by a roll having alternating raised and indented parts.

The lining is suitably manufactured from a sheet material comprising aramid fibres, which has a thickness of approximately 0.2 - 0.5 mm.

The advantageous embodiments of the method according to the invention described above, and other advantageous embodiments, are defined in the sub-claims to claim 15.

The invention will now be explained in more detail in the following description of advantageous embodiments, with reference to the accompanying drawings in which

Figure 1 shows schematically an axial end view of a sector of the stator in a machine according to the invention,

Figure 2 is a partial enlargement of a detail from Figure 1 showing part of a slot,

Figure 3 shows an alternative embodiment of the slot profile in a view corresponding to Figure 2,

Figure 4 shows an alternative embodiment of the lining according to the invention,

Figure 5 illustrates a step in the manufacture of a lining according to the invention,

Figure 6 illustrates the profile of a lining according to the invention in axial section,

Figure 7 is a section along the line VII-VII in Figure 6, and

Figure 8 is a cross section through a conductor used in the machine according to the invention.

In the schematic axial view in Figure 1 through a sector of the stator 1 of the machine, its rotor is designated 2. The stator is composed in conventional manner of a laminated core of sheet steel divided into sector-shaped sections, one of which is shown in the figure. From a yoke portion 3 of the core situated radially outermost, a number of teeth 4 extend radially in towards the rotor 2 and are separated by slots 5 in which the stator winding is arranged. In this machine intended for high voltage the slots 5 have considerably

greater depth than what is usual. The cables 6 in the windings are high-voltage cables which may be of substantially the same type as high-voltage cables used for power distribution, so-called crosslinked polyethylene (XLPE) cables. One difference is that the outer mechanically protective sheath that normally surrounds such a cable has been eliminated. The cable thus comprises only the conductor, an inner semiconductor layer, an insulating layer and an outer semiconducting layer. The semiconductor layer, sensitive to mechanical damage, is thus exposed on the surface of the cable.

In the drawings the cables 6 are illustrated schematically, only the conducting central part of the cable part or coil side being drawn in. As can be seen, each slot 4 has varying cross section with alternating wide parts 7 and narrow parts 8. The wide parts 7 are substantially circular and surround cable parts, and the waist parts between these form narrow parts 8. The waist parts serve to radially position each cable part. The cross section of the slot as a whole also becomes slightly narrower in radial direction inwards. This is because the voltage in the cable parts is lower the closer they are situated to the radially inner part of the stator. Slimmer cable parts can therefore be used here, whereas increasingly coarser cable parts are required further out. In the example illustrated cables of three different dimensions are used, arranged in three correspondingly dimensioned sections 9, 10, 11 of the slots 5.

Figure 2 shows how a lining 12 according to the invention is arranged abutting the walls of the slot 5. The lining is made of profile-rolled, hard-calendered aramid fibre, e.g. of the type known under the trade name Nomex™, but may alternatively be made of glassfibre, reinforced epoxy, thermoset plastic or the like. Nomex™ is available in a standard thickness of 0.17 mm and a suitable thickness for the lining lies in the interval 0.1 - 1.0 mm. The lining material should have good thermal conducting properties and may either be electrically insulating or manufactured with a certain resistivity to earthing inside the slot.

As is clear from the figure, the lining 12 has a profile corresponding to the profile of the slot walls with their alternating narrower parts 8 and wider parts 7. The figure illustrates how the cable is composed of a conductor 6a in the core, preferably formed of twisted copper strands, surrounded

by a semiconductor layer 6b, an insulating layer 6c and an outer semiconductor layer 6d. The purpose of the lining is to eliminate the risk of damage to the outer semiconductor layer 6d. Such damage may occur during winding of the cable when the cable is inserted through the slot with the risk of being scratched against the edges of the steel sheets and also due to wear caused by vibration and thermal movement of the cable.

Figure 3 shows an alternative embodiment of the slot profile where alternate waist parts 8 are in the form of a "half" waist since one wall of the slot runs in a tangential plane 13 to two adjacent circular parts. The lining 12 has a corresponding shape.

Figure 4 shows an alternative embodiment in a section corresponding to that shown in Figure 2, but constituting an enlarged detail section of only one slot wall. In this embodiment the lining 12 has two layers 12a, 12b of aramid fibre. Between these a rubber layer 14 is arranged. The purpose of the rubber layer is to yieldingly position the cable, thus absorbing vibrations therein. The rubber layer need not be coherent but may be replaced with a number of separate rubber elements between the aramid layers. The rubber layer or rubber elements adhere to the aramid layer by means of a glue which releases at approximately 60°C. Some other material with equivalent elastic properties may naturally be used instead of rubber. Alternatively the aramid fibre layer itself may be made with equivalent elasticity.

For the sake of clarity the lining 12 in Figures 2 - 4 has been shown with spaces to the slot walls and to the cable 6 but it should be understood that they are in fact in contact.

Figure 5 illustrates a step in the manufacture of a lining intended for use in the slots of a machine according to certain embodiments of the present invention.

A sheet of aramid fibre, e.g. Nomex™ with a thickness of approximately 0.5 mm, cut to suitable dimensions, is hot-moulded between a rotating cylinder 21 and a moulding tool 22. The figure illustrates moulding a lining covering the entire inner surface of the slot, i.e. both its wall surfaces. The middle 27 of the cylinder will thus represent the part of the lining which will lie at the bottom of the slot. When moulding is complete the lining is folded or bent around the mid-line of the rolled sheet and the fold is given a radius of

curvature corresponding to that in the bottom of the slot. The sheet may possibly be thinner at its mid-point during the rolling, or it may be provided in some other way with markings to facilitate folding.

The cylinder consists of a number of rollers 23 having concave cylindrical profile 25 which are joined together, and the moulding tool 22 has a shape conforming with the ball-shaped counter-supports 24 for the cylindrical parts of the lining and cylindrical pins 26 between them for the waist parts of the lining. The rollers 23 of the cylinder 21 have different profile radii, the rollers situated nearest the mid-point 27 having the largest radius, those situated furthest out having the smallest radius and those situated between having a radius between the other radii. This is in order to produce a profile in the lining which corresponds to the various cable dimensions used in the slot, as described in connection with Figure 1.

When the aramid-fibre sheet has been given its profile in the hot-moulding process and then folded at about its mid-line, it will have the shape illustrated in Figure 6, folded at the lower end (bottom of the slot) and open at the top (slot opening). Shaped thus, the lining can easily be compressed and inserted axially into the slot, where it will snap out to fit against the slot walls.

The lining is suitably given an axial extension greater than the axial length of the slot so that a short portion 30, 31 protrudes outside the slot at one or both ends. This can then be folded out as shown in 30 to ensure that the lining is not displaced in axial direction.

Figure 8 shows a cross-sectional view of a high-voltage cable 6 according to the present invention. The high-voltage cable comprises a number of strands 31 of copper (Cu), for instance, having circular cross section. These strands 31 are arranged in the middle of the high-voltage cable 6. Around the strands 31 is a first semiconducting layer 32, and around the first semiconducting layer 32 is an insulating layer 33, e.g. XLPE insulation. Around the insulating layer 33 is a second semiconducting layer 34. Thus the concept "high-voltage cable" in the present application does not include the outer protective sheath that normally surrounds such cables for power distribution.

CLAIMS

1. A rotating electric high-voltage machine, the stator winding of which comprises high-voltage cables (6) arranged in radial slots (5) in the core of the stator (1), characterized in that at least one of said slots (5) is provided with a lining (12) of thermoformable material, which lining (12) in axial section has a profile corresponding to the profile of the slot (5), and in that the winding comprises an insulation system including at least two semiconducting layers, each layer constituting essentially an equipotential surface and also including solid insulation disposed therebetween.

2. A machine as claimed in claim 1, wherein at least one of the layers has substantially the same coefficient of thermal expansion as the solid insulation.

3. A machine as claimed in claim 1 or 2, arranged for direct connection to a power network without intermediate transformers.

4. A machine as claimed in any of claims 1-3, wherein at least one of said slots (5) in a radial section through the stator (1) has varying width in radial direction, with alternating narrower (8) and wider (7) parts, and wherein said lining (12) has a corresponding profile.

5. A machine as claimed in claim 4, wherein at least one of said slots (5) in a radial section through the stator (1) has a profile similar to that of a bicycle chain, and wherein said lining (12) has a corresponding profile.

6. A machine as claimed in any of claims 1-5, wherein said lining material is fibre-reinforced.

7. A machine as claimed in claim 6, wherein said fibres consist of aramid fibres.

8. A machine as claimed in any of claims 1-7, wherein said lining (12) has a thickness of between 0.1 and 1.0 mm.

9. A machine as claimed in claim 8, wherein said lining (12) has a thickness of between 0.17 and 0.5 mm.

10. A machine as claimed in any of claims 1-7, wherein said lining (12) comprises spring means (14) on at least one side of the slot.

11. A machine as claimed in claim 10, wherein said lining (12) comprising spring means (14) is in the form of a laminate with at least two layers (12a, 12) of said material, between which layers said spring element (14) is arranged.

12. A machine as claimed in claim 11, wherein said spring element (14) consists at least partially of a material having high elasticity.

13. A machine as claimed in any of claims 1-12, wherein said lining (12) is made of insulating material.

14. A machine as claimed in any of claims 1-12, wherein said lining (12) is made of a material having a resistivity suitable for earthing a semiconducting outer layer (34) of the cable (5).

15. A machine as claimed in any of claims 1-14, wherein said lining (12) protrudes outside at least one end surface of the stator (1) and wherein its protruding part (30, 31) has a profile with greater width in the peripheral direction of the stator than the width of its part which is situated in the slot.

16. A rotating electric high-voltage machine, the stator winding of which comprises high-voltage cables (6) arranged in radial slots (5) in the core of the stator (1), characterized in that at least one of said slots (5) is provided with a lining (12) of thermoformable material, which lining (12) in axial section has a profile corresponding to the profile of the slot (5), and in that said winding is formed of a cable comprising one or more current-carrying conductors, each conductor having a number of strands, an inner semiconducting layer provided around each conductor, an insulating layer of solid insulating material provided around said inner semiconducting layer, and an outer semiconducting layer provided around said insulating layer.

17. A method for manufacturing and applying lining in a radial slot with high-voltage cables arranged in the stator of a rotating electric machine, characterized in that

- a sheet of a thermoformable material is available,
- the sheet is cut to a suitable size,

- the cut sheet is hot-moulded to a profile in agreement with the profile of the side walls of the slot,
- after which the hot-moulded sheet is applied in the slot.

18. A method as claimed in claim 17, wherein before being applied in the slot, the hot-moulded sheet is bent around a symmetry line to a shape corresponding to the cross-section shape of the slot.

19. A method as claimed in claim 17 or claim 18, wherein the sheet is hot-moulded between an indented roll and a corresponding indented moulding tool.

20. A method as claimed in any of claims 17-19, wherein the sheet is cut to a size equivalent to the entire inner surface of the slot.

21. A method as claimed in any of claims 17-20, wherein the ready-shaped sheet is applied in the slot by being inserted axially therein from one side of the stator.

22. A method as claimed in any of claims 17-21, wherein the sheet is hot-moulded between a cylinder having a plurality of circular, concave parts, and a moulding tool having conforming circular, convex parts.

23. A method as claimed in any of claims 17-22, wherein the sheet is cut somewhat longer in the direction corresponding to the axial extension of the slot than the length of this extension.

24. A method as claimed in any of claims 17-23, wherein a sheet material that is aramid-fibre reinforced is made available.

25. A method as claimed in any of claims 17-24, wherein a sheet having a thickness of 0.1 - 0.5 mm is made available.

Fig. 1

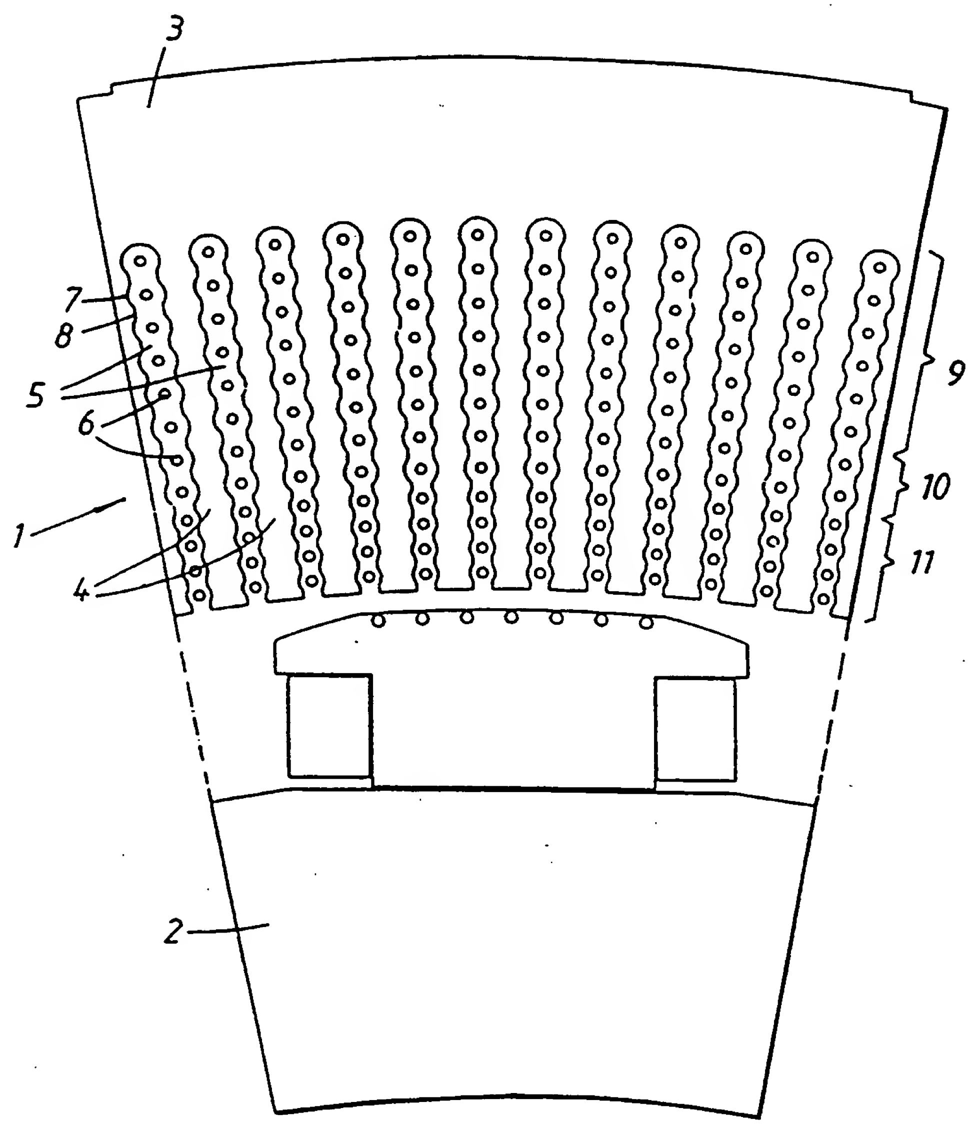


Fig. 2

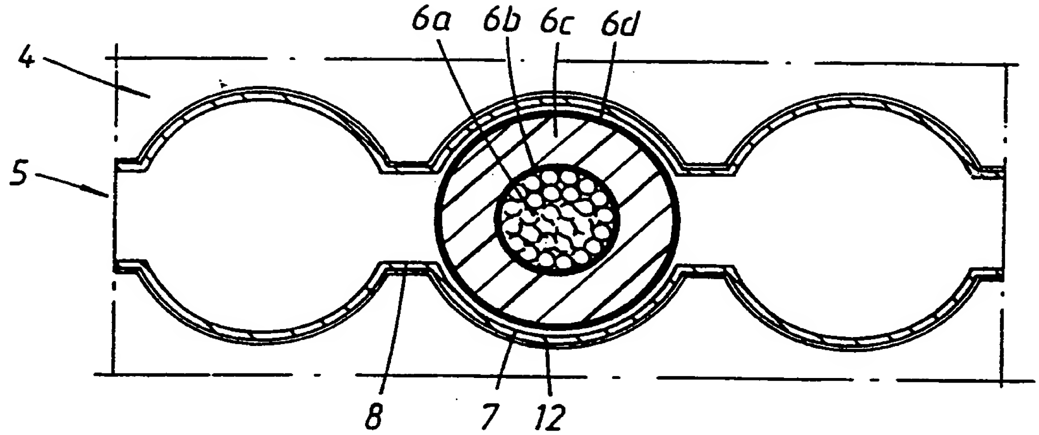


Fig. 3

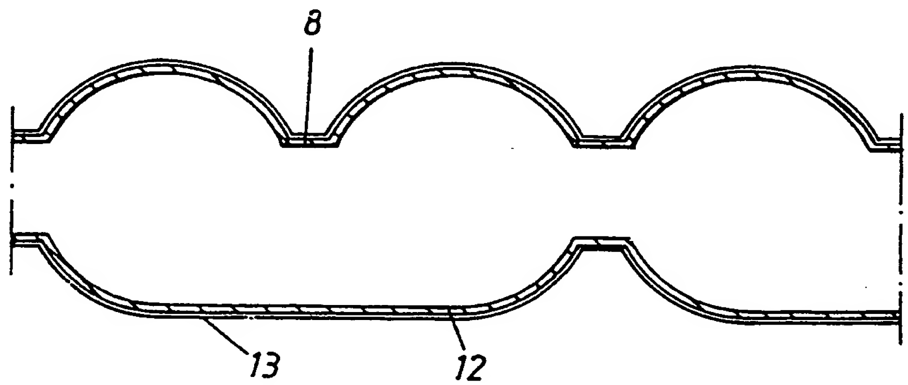


Fig. 4

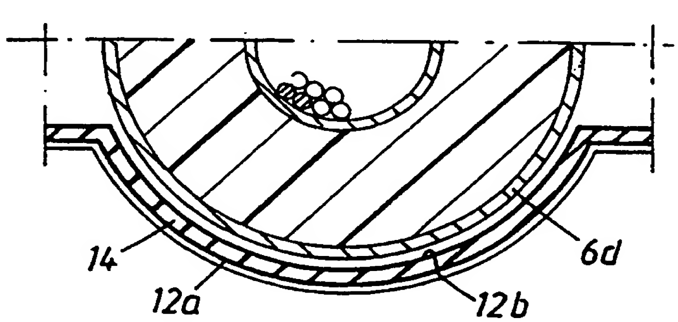


Fig. 5

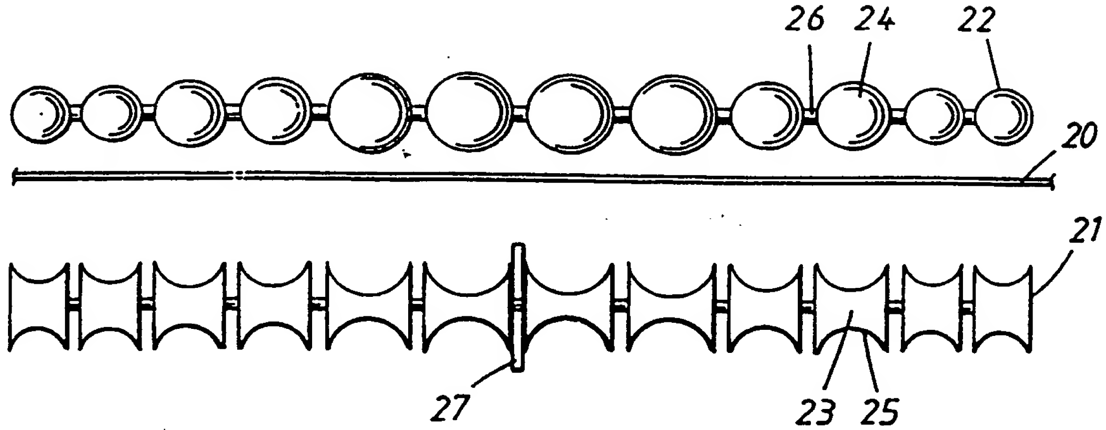


Fig. 6

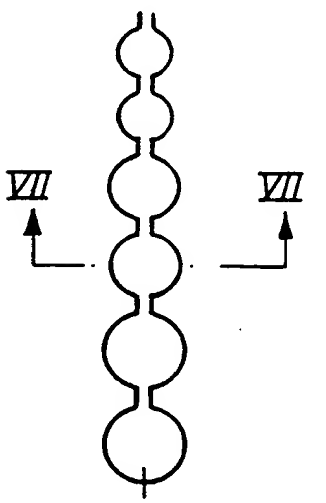


Fig. 7

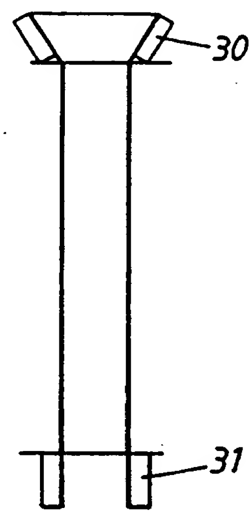
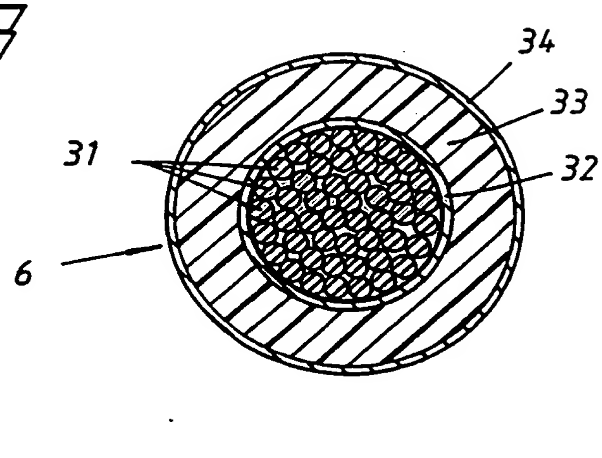


Fig. 8



THIS PAGE BLANK (USPTO)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00896

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 3/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5036165 A (RICHARD K. ELTON ET AL.), 30 July 1991 (30.07.91), see the whole document --	1-25
Y	US 3943392 A (JOHN J. KEUPER ET AL.), 9 March 1976 (09.03.76), see the whole document --	1-25
Y	US 5325008 A (JAMES J. GRANT), 28 June 1994 (28.06.94), abstract --	10-12
Y	US 3130335 A (L.J. REJDA), 21 April 1964 (21.04.64), column 1, line 30 - line 36; column 1, line 53 - line 63 --	1-25

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" erlier document but published on or after the international filing date

"L" document which may throw douhts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 Sept 1997	26 -09- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anders Axberger Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00896

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 1974406 A (V.G. APPLE), 25 Sept 1934 (25.09.34), page 1, line 53 - line 67	1-25
A	US 4560896 A (GEORGE H. VOGT ET AL.), 24 December 1985 (24.12.85), abstract	1-24
A	DE 4023903 C1 (PIUR, ARMIN ET AL.), 7 November 1991 (07.11.91), abstract	1-25

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/09/97

International application No.
PCT/SE 97/00896

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5036165 A	30/07/91	US 5066881 A	19/11/91
		US 5067046 A	19/11/91
		CA 1245270 A	22/11/88
		US 4853565 A	01/08/89
US 3943392 A	09/03/76	CA 1033396 A	20/06/78
		DE 2550806 A,C	12/08/76
		FR 2293097 A,B	25/06/76
		GB 1502845 A	01/03/78
		JP 51077803 A	06/07/76
		SE 415718 B,C	20/10/80
		SE 7512458 A	28/05/76
US 5325008 A	28/06/94	CA 2103422 A	10/06/94
		EP 0601827 A	15/06/94
		JP 6237549 A	23/08/94
US 3130335 A	21/04/64	NONE	
US 1974406 A	25/09/34	NONE	
US 4560896 A	24/12/85	CH 671659 A,B	15/09/89
		JP 61088737 A	07/05/86
DE 4023903 C1	07/11/91	CH 683049 A	31/12/93